

Aug. 14, 1956

C. D. CUPP

2,758,596

PORTABLE BREATHING APPARATUS OF THE DEMAND TYPE

Filed May 24, 1954

4 Sheets-Sheet 1

Fig. 2.

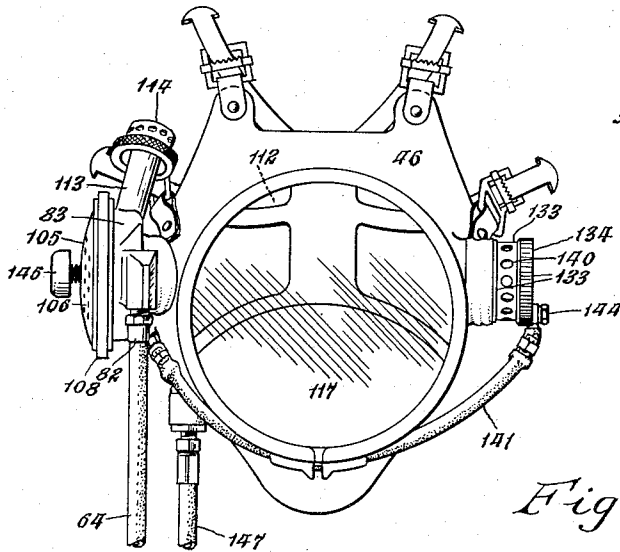


Fig. 1.

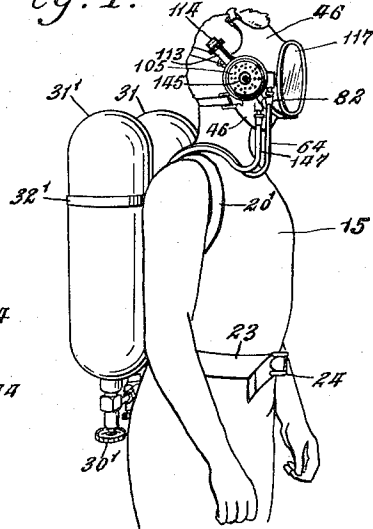


Fig. 4.

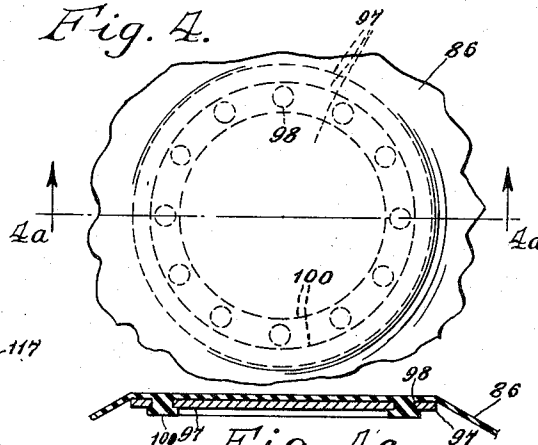


Fig. 3.

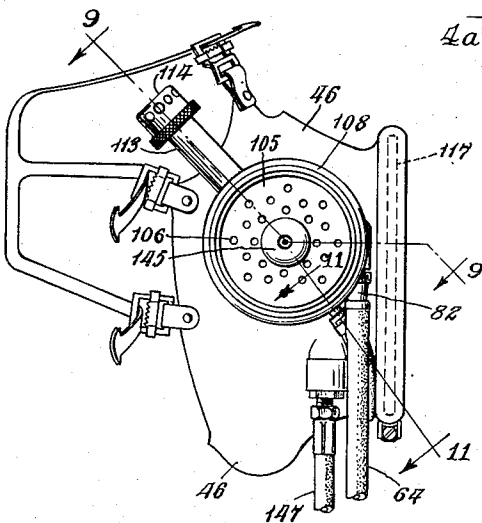


Fig. 4a.

Fig. 5.

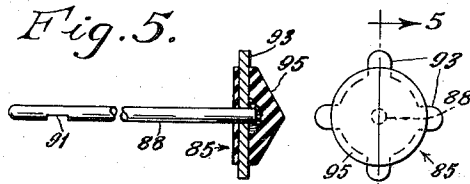


Fig. 5a.
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4 Sheets-Sheet 3

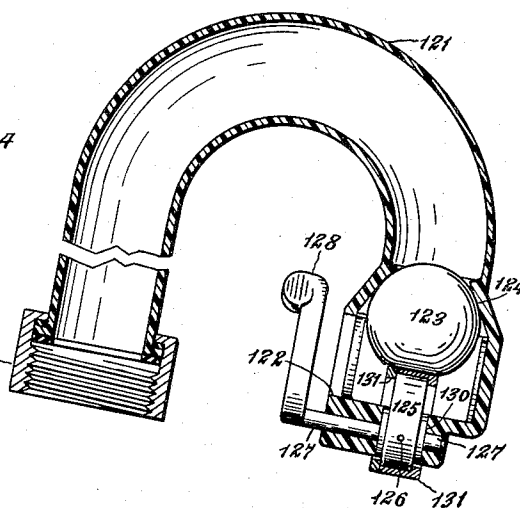
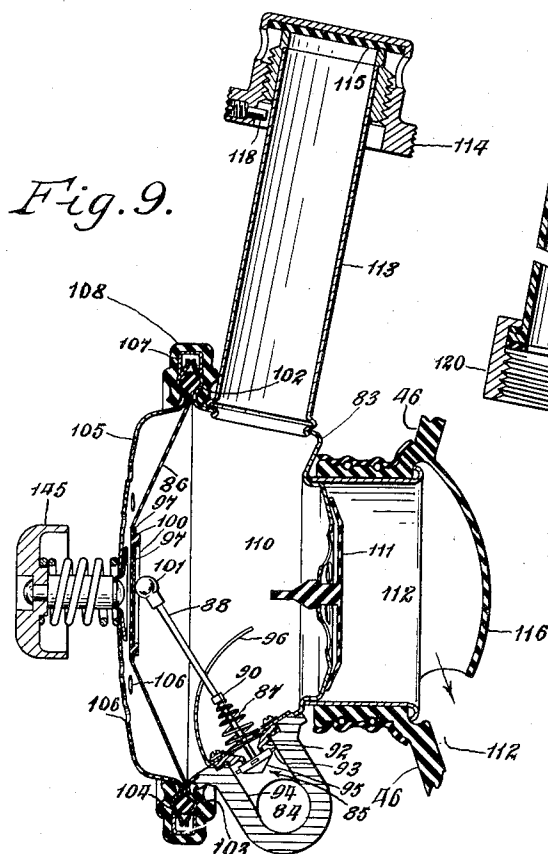
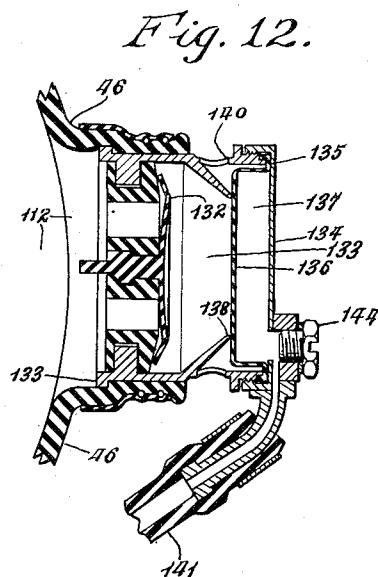
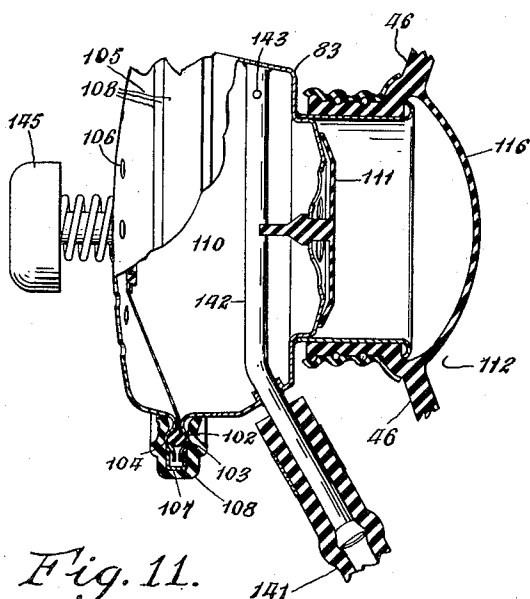


Fig. 10.



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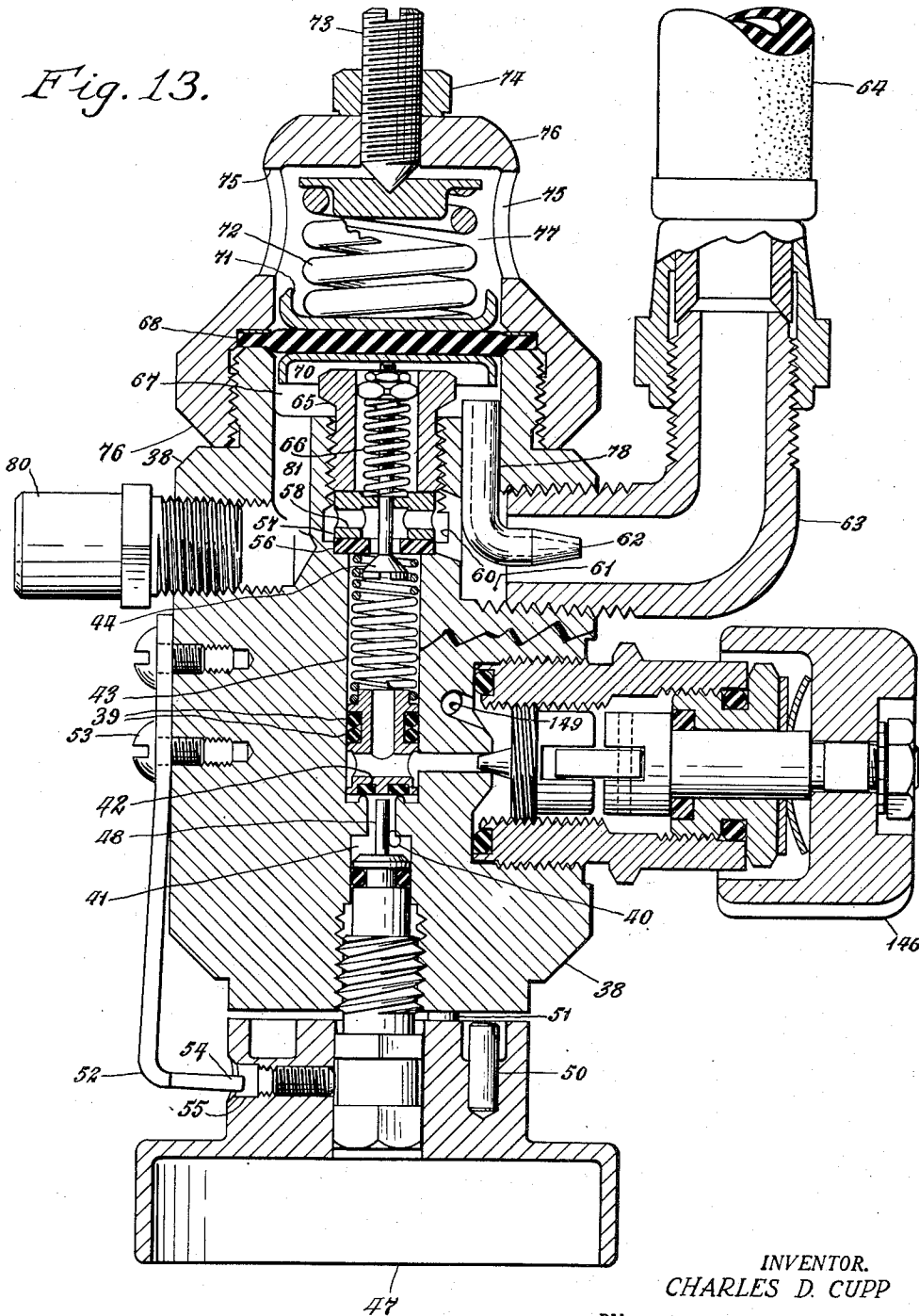
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PORTABLE BREATHING APPARATUS OF THE DEMAND TYPE

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4 Sheets-Sheet 4

Fig. 13.



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2,758,596

PORTABLE BREATHING APPARATUS OF THE DEMAND TYPE

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Application May 24, 1954, Serial No. 431,806

8 Claims. (Cl. 128—142)

This invention relates to a breathing apparatus which can be used either above or below the surface of the water, but relates more particularly to an underwater, breathing apparatus of the demand type which is portable and self-contained and employs compressed air as the inhaled breathing fluid, with the exhaled, foul air being discharged through an exhalation valve into the ambient medium.

The invention preferably includes a full-face underwater mask, but the invention is not confined to the use of such a mask.

The present patent application is a continuation-in-part of my U. S. patent application entitled "Underwater Breathing Apparatus," Ser. No. 362,065, filed in the U. S. June 16, 1953.

The principal objects of the invention are to provide a portable, self-contained, breathing apparatus:

1. Which will permit of being completely donned above water and yet permit the diver, in an emergency, to instantly slip under the surface of the water without any preliminary adjustments of the breathing apparatus.

2. Which will enable the diver to put on his mask, if desired, underwater and then enable him to instantly discharge all the water from in the mask.

3. Which will prevent any uneconomic loss of breathing fluid, irrespective of the position of the diver in the water.

4. Which will permit of easily and quickly disassembling or assembling the demand regulator without the use of tools.

5. Which will permit the freest possible flow of breathing fluid past the demand valve and yet permit the latter to be operated with a minimum of pressure.

Other collateral objects of the invention and practical attainments thereof are described in the following description and illustrated in the appended drawings in which:

Fig. 1 is a diminutive, perspective view of a diver equipped with the present invention.

Fig. 2 is a front elevation of the face mask and its appurtenances.

Fig. 3 is a side elevation of said mask.

Fig. 4 is a greatly enlarged, fragmentary elevation of the central part of the demand diaphragm.

Fig. 4a is a transverse, medial section thereof, taken on line 4a, Fig. 4.

Fig. 5 is a greatly enlarged, longitudinal section through the demand valve, taken on line 5, Fig. 5a.

Fig. 5a is an end elevation thereof.

Fig. 6 is a rear elevation of the back plate with its compressed air tanks etc. in place.

Fig. 7 is a horizontal section thereof taken on line 7, Fig. 6.

Fig. 8 is an enlarged, horizontal section taken just above the reduction valve casing on line 8, Fig. 6.

Fig. 9 is an enlarged, fragmentary, substantially-vertical section through the mask, taken on line 9, Fig. 3.

Fig. 10 is an enlarged, longitudinal, medial section through the snorkel attachment.

Fig. 11 is an enlarged, fragmentary, substantially-ver-

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cal section through the inlet portion of the mask, taken on line 11, Fig. 3.

Fig. 12 is an enlarged, fragmentary, substantially-vertical section taken on approximately the same section line as Fig. 11, but taken through the exhalation valve and its appurtenances on the opposite side of the mask.

Fig. 13 is a greatly enlarged, vertical, longitudinal section through the reduction valve casing taken on line 13, Fig. 8.

The "frogman" or diver 15 (Fig. 1) has detachably secured to his back a flat and substantially rectangular back plate 16. The latter is provided at its opposite, upper corners with a pair of rectangular, upper openings 17, 17¹ and at its opposite lower corners with a pair of rectangular lower openings 18, 18¹. Passing through said upper openings and detachably secured to the back plate by detachable belt fastenings or retainers 19, 19¹ is a pair of flexible shoulder straps 20, 20¹. Passing through the lower openings 18, 18¹ of the back plate 16 is a hold-down strap 21 whose opposite ends are adjustably connected with the lower ends of aforesaid shoulder straps 20, 20¹, the adjustment being effected by the usual slide buckles 22, 22¹. This arrangement comfortably supports the back plate 16 and its appurtenances upon the shoulders of the diver when he is walking, and also holds the upper part of the back plate firmly in position when he is swimming. The lower part of said back plate is held firmly against the small of the diver's back by a belt 23 which passes through the same lower openings 18, 18¹ as the hold-down strap 21. The latter is provided with the usual belt buckle 24.

The extreme lower end of the back plate is bluntly tapered and terminates at its extreme, lower, straight edge in a pair of rearwardly-bent, integral, symmetrically-disposed ears 25, 25¹, upon the upper faces of which is clamped a pair of short nipples or breathing fluid pipes 26, 26¹. This clamping is effected by a pair of sheet metal clips which are held in place by a pair of bolts 27, 27¹.

The outer ends of the breathing pipes 26, 26¹ are provided with companion detachable unions 28, 28¹ whose outer ends are connected to the casings of a pair of shut-off valves 30, 30¹. These valves are screwed into the lower end of companion, cylindrical storage tanks 31, 31¹ whose upper ends are embraced by companion flexible bands 32, 32¹. The opposite ends of each of the latter are clamped together by companion clamp screws 33, 33¹ whose outer ends are pivotally connected to the outer ends of their companion flexible bands 32, 32¹, while the inner ends of said clamp screws are detachably clamped to the inner ends of their flexible bands by wing nuts 34, 34¹.

The adjacent inner parts of the flexible bands 32, 32¹ are welded or otherwise secured to the opposite, outer, concave portions of a pair of sheet-metal, bifurcated cleats 35, 35¹ whose inwardly projecting arms overlap each other. Secured to the outer, upper face of the back plate 16 (as by rivets 29) is U shaped, sheet-metal bracket 36 and through the center of said bracket is passed a clamping bolt 37 which also passes through all four arms of the bifurcated cleats 35, 35¹. This arrangement firmly holds either one or both of the flexible bands 32, 32¹ to the back plate 16, and, as each of said flexible bands is adapted to detachably clasp the upper end of a companion storage tank 31, 31¹, it follows that the upper end of either one or the upper ends of both of said storage tanks are detachably secured to the upper rear face of the back plate 16. This construction permits of using storage tanks of widely varying diameters.

The inner ends of the breathing fluid pipes 26, 26¹ are screwed into a reduction valve casing 38 of hexagonal cross section. The compressed air in the storage tanks

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31, 31¹ passes through either one or both of their shut-off valves 30, 30¹ and their companion breathing fluid pipes 26, 26¹ and thence through the holes 40 (only one is shown) of the reduction valve casing 38 into the coaxially-located, cylindrical, inlet chamber 41 of said casing. When the pressure in this inlet chamber 41 is relatively high, it is able to move upwardly past the spring-loaded, check valve 42 and thence into the intermediate pressure chamber 43.

The lower end of this check valve 42 is hexagonal in cross section so as to allow the air to flow past said lower end and into the hollow interior of said check valve. As this check valve opens in the same direction as the flow of the air there is a tendency for it to flutter, and this is prevented by a pair of O rings 39 which are tightly received within a suitable annular groove formed in the periphery of said check valve 42. These O rings 39 do not function in the manner of ordinary O rings with the object of preventing leakage but are tightly received in aforesaid annular groove of the check valve 42 so as to frictionally resist any tendency of the check valve to flutter, but without, however, materially impeding the free movement of said check valve resulting from the differential of the air pressures acting upon its opposite ends. When the pressure in the inlet chamber 41 has dropped a certain amount, due to a partial depletion of air pressure in the one or other or in both of the air storage tanks 31, 31¹ (depending on the setting of the shut-off valves 30, 30¹), the check valve 42 will close, and will thereby cut off the air being supplied to the diver's mask 46. This will notify him that the pressure in the inlet chamber 41 is down to a certain "reserve" pressure. If, for simplicity, we assume that he has already opened both of the shut-off valves 30, 30¹, he will automatically have been informed that he is down to his reserve supply of compressed air, and he will then turn the knob 47 of the check-valve, unseating pin 48, thereupon causing the check valve 42 to be unseated and thereby providing him with the reserve supply of air from his air storage tanks.

Excessive upward movement of the unseating pin 48, and also any accidental complete unscrewing of it, is prevented by a stop pin 50 mounted on knob 47 this pin 50 being adapted to strike the one or other side of an abutment pin 51 that projects downwardly from the lower face of the reduction valve casing 38. Thus said knob 47 has two operative positions and it is held in the one or other of these two positions by a sheet-metal, resilient, detent arm 52 which is secured to the reduction valve casing 38 by cap screws 53. Said detent arm 52 is also provided at its extreme lower end with an integral, stamped-out, semi-cylindrical, detaining tongue 54 which is adapted to resiliently engage itself with the one or other of a pair of detent holes 55 (only one is shown) which are formed radially in the hub of the knob 47.

At the upper end of the intermediate pressure chamber 43 is a reduction valve 44 which is adapted to seat itself on a ring-shaped, nylon, valve seat 56. The latter is received coaxially within an upwardly-facing, annular recess that is formed in the reduction valve casing 38. Resting upon the upper surface of said valve seat 56 is a hollow, annular, spacer block 57 having a plurality of radial, air-transfer passages 58 which carry the air from its hollow interior out to an annular counterbore or balancing chamber 60 which latter is formed coaxially in the reduction valve casing 38. The air in said counterbore 60 passes out through a radial passage 61 (formed in the reduction valve casing 38) and thence past a venturi nozzle 62 and into a tubular elbow 63 from which it flows through a flexible, main hose 64 up to the mask 46.

The annular spacer block 57 is held down firmly in place by a hollow, externally threaded bushing 65 which encloses both the stem of the reduction valve 44 and also the light compression spring 66 which gently urges

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said reduction valve toward its closed position. The upper end of the bushing 65 opens up into what might be termed a pocket chamber 67, and it should be noted at this point that the stem of the reduction valve 44 is received within a relatively close, sliding fit in the upper part of the spacer block 57. Hence the only appreciable communication between the pocket chamber 67 and the balancing chamber 60 is through the venturi nozzle 62, and, therefore, the only time the pressures in these two chambers are equal is when there is no flow of air through said balancing chamber 60. When there is a flow of air through said balancing chamber 60 its pressure is greater than the pressure in the pocket chamber 67 by an amount geometrically proportional to the speed of flow of air through said balancing chamber and into the main hose 64.

Arranged above the pocket chamber 67 is a flexible diaphragm 68 against the lower face of which is arranged a cup or flanged metal plate 70 whose lower face lies upon the upper end of the stem of the reduction valve 44. Lying upon the upper face of the diaphragm 68 is another cup or flanged metal plate 71 upon whose upper face rests a very heavy compression spring 72. The resilient force exerted by said spring 72 upon the top of the diaphragm 68 is adjusted by an adjustment screw 73 and the adjustment locked in place by a suitable lock nut 74.

The upper face of the diaphragm 68 is exposed to whatever ambient fluid the diver may happen to be immersed in by reason of the openings 75 which are formed in the hollow cap 76 that is screwed onto the top end of the reduction valve casing 38 the hollow interior of said cap constituting ambient chamber 77. With this arrangement, when the diver is below the surface of the water, the pressure exerted upon the top face of the diaphragm 68 is directly proportional to the depth of the diver below the surface. In other words the deeper he goes the greater the air pressure in the balancing chamber 60.

It is highly desirable that the pressure in the balancing chamber 60 be the same as that in the mask 46, but this desirable condition would, unless otherwise compensated for, be harmfully affected by the fact that the pressure drop through the main hose 64 increases with an increase of the speed of flow through it. This change in the pressure drop is compensated for by the venturi nozzle 62 which increasingly reduces the pressure below the diaphragm 68 as the speed of flow through the main hose 64 is increased, i. e., an increased pressure is exerted to open the reduction valve 44 as the speed of air through the main hose 64 is increased.

It should be observed at this point that the foregoing effect does not require a venturi nozzle 62, and that a very high degree of venturi effect is obtained by merely having the pocket chamber 67 in lateral communication with the flow from the balancing chamber 60, by, for instance, eliminating entirely the venturi nozzle 62 together with its integral, upstanding, communication tube 78, but otherwise having the parts arranged as shown.

If, accidentally, the pressure in the balancing chamber 60 should become excessively high, the excess pressure is bled off through a relief valve 80 which communicates with the pocket chamber 67 through a drilled hole 81.

The main hose 64 runs up from the elbow 63 and passes through the hollow interior of the U shaped bracket 36 (to prevent getting tangled up with the diver or the rest of the equipment) and then droops over the right shoulder of the diver (to allow him to move his head freely) and then passes upwardly to a terminal tube fitting 82 which is screwed into the front side of the sheet metal casing of the regulator 83. The air then flows into a demand valve compartment 84 and up past the tiltable demand valve 85, whenever the latter is opened by the flexible diaphragm 86.

This demand valve 85 is resiliently urged toward its closed position by a conical compression spring 87 whose

apex is secured to the stem 88 of the demand valve by a short sleeve 90 which is crimped into a notch 91 formed on the stem 88 of the demand valve. The latter is adapted to seat itself on a metal demand valve seat 92, and it is to be particularly noted that nothing directly connected with this valve seat has anything to do with the centering of the demand valve. This centering is effected by providing the demand valve with a plurality of guide tits 93 (Fig. 5a) which slidably engage the cylindrical bore 94 of the demand valve compartment 84. The entire demand valve, except for its stem 88 and protruding guide tits 93 is encased in molded rubber 95 so as to provide a soft seat upon the metal valve seat 92. Any interference by the diaphragm 86 with the action of the demand valve is prevented by a curved, sheet metal guard 96.

The central part of the diaphragm 86 has integrally molded to it (Figs. 4 and 4a) a hard plate or metal disk 97 in which is formed a peripheral row of holes 98 through which the unvulcanized rubber flows during the molding operation and thence flows further outwardly to form an annular retaining head 100 whose width is greater than the diameter of the holes 98 and thereby integrally binds the disk 97 to the diaphragm 86. The reason for this disk is to reduce friction between the diaphragm, taken as a whole, and the ball tip 101 of the demand valve stem 88.

Integrally molded in the rim of the diaphragm is a peripheral bead 102 which is of circular cross section. This bead is received within a pair of semi-circular, annular grooves 103 and 104 which are formed peripherally in the main regulator casing 83 and its metal cover 105. The latter is also provided with perforation 106. Outwardly of these annular grooves 103 and 104 the sheet metal of the main casing 83 and its cover 105 are formed annularly conical, and these conical surfaces are engaged by a metal, U shaped, resilient, clamping ring 107 which is split radially on one of its sides so as to enable it to be opened up and then snapped over the aforesaid pair of conical surfaces. This holds the diaphragm bead 102 snugly in place. To ensure that the joint between the diaphragm bead 102 and the regulator casing 83 will be water tight, and also to prevent accidental disengagement of the clamping ring 107, the latter is covered by a U shaped, resilient, sealing ring 108.

Whenever the ambient pressure on the outer surface of the diaphragm 86 is higher than the pressure in the mask 46 the diaphragm will be pushed inwardly and the demand valve 85 tilted to its open position. This permits compressed air to pass from the demand valve into the inlet chamber 110 and thence past the inlet check valve 111 into the breathing chamber 112 of the mask.

Projecting upwardly and rearwardly from the regulator casing 83 is a sheet metal air inlet duct 113 upon whose upper end is threaded a cap or economizer valve 114 having the washer 115 and shown in closed position in Fig. 9. When the diver is above the surface of the water and wishes to conserve his supply of compressed air, he partially unscrews this cap 114 and thereby opens up the inlet duct 113 to ambient air. Under these conditions the diaphragm 86 remains in its outer position because both of its faces are subjected to the same, ambient air pressure and hence all breathing air is inhaled through the air inlet duct 113.

If, with the cap 114 still in its open position, the diver should suddenly be forced to dive under water (or fall overboard), he can do this safely because the water pressure on the outer face of the diaphragm 86 will open the demand valve 85 and prevent the ingress of any considerable amount of water past the cap 114 until, while still underwater, the diver closes said cap and prevents any further loss of compressed air.

Just inwardly of the inlet check valve 111, the mask is provided with an integral baffle 116 which directs the incoming air forwardly against the rear face of the

transparent, circular, face piece 117 and thereby preventing fogging of the latter.

Instead of using the cap 114 conditions may be such as to warrant the use, in place of said cap, of the snorkel device of Fig. 10. To do this the limiting screw 118 of the cap 114 is first unscrewed and then said cap unscrewed entirely and replaced by the internally threaded collar 120 of the snorkel tube 121. The latter is preferably curved so as to bring its inlet openings 122 directly above the head of the diver when he is in normal swimming position. In the enlarged, outer or inlet end of the snorkel tube 121 is a hollow, rubber or other buoyant ball 123 which, when submerged, seats itself on its valve seat 124 so as to automatically close when the diver drops below the surface of the water. This, however, only operates properly if the diver stays within say 60° of his normal swimming position and for this reason it is desirable to be able to positively close the inlet end of the snorkel tube 121. This result is inexpensively effected by the use of a circular eccentric 125 secured by pin 126, or otherwise, to a transverse shaft 127 which is suitably journaled in the snorkel tube just below the buoyant ball 123 and manually actuated by a handle 128. To prevent accidental movement of said handle 128 a pair of resilient C washers 130, or their equivalent, are preferably provided. It is also desirable to surround the circular eccentric 125 with a circumferentially slidable rim 131 so as to not thrust the buoyant ball 123 sidewise while pushing it up into the closed position shown.

On the left side of the breathing mask 46 (Fig. 12) is a main exhalation valve 132 for venting exhaled air from the breathing chamber 112 out into the ambient medium which surrounds the diver. The casing 133 of this main exhalation valve extends out beyond said main exhalation valve and is externally threaded to receive a threaded cover 134, between which and the outer end of the casing 133 is clamped the outwardly extending flange 135 of a cup-shaped, flexible, control exhalation valve 136. The hollow space between the outside face of the vertical wall of this control exhalation valve 136 and the inner face of the cover 134 may be denominated an exhalation balancing chamber 137. The valve seat 138 of the control, exhalation valve 136 has a diameter appreciably less than the total diameter of said control, exhalation valve. Consequently, the pressure of the exhaled air at the exit end of the main exhalation valve must be greater than the pressure in the exhalation, balancing chamber 137, before any exhaled air can flow past both of said valves and thence pass out through the apertures 140 of the valve casing 133.

The pressure in the exhalation balancing chamber 137 is always the same as the pressure in the inlet chamber 110 of the mask. This is because these two chambers are always in direct communication with each other through a balancing tube 141 (or its equivalent), the right end of which (Fig. 11) is connected with an upstanding tube 142 which vertically and internally spans the regulator casing 83 and has its openings 143 located well above the floor of the inlet chamber 110 so as to minimize any chance of water flowing from said inlet chamber into the balancing tube 141. If any appreciable amount of water should get into this tube the diver drains out the same by putting the left side of his mask down and opening the threaded drain plug 144.

One of the reasons for this balancing tube 141 is to obtain the most efficient functioning of the entire breathing apparatus when the diver is underwater with the right side of the mask positioned below the main exhalation valve 132. Under these conditions there is a relatively high water pressure on the outside surface of the diaphragm 86 and a relatively low water pressure at the exhalation side of the mask. This, if not properly compensated for, would result in an excessive venting of air through the main exhalation valve 132. The present invention compensates for this by increasing, under these

conditions, the air pressure in the exhalation, balancing chamber 137, thereby preventing any egress of air from the mask until the pressure in the breathing chamber 112 has risen to a point where it can be effectively used by the diver before being exhaled.

Another virtue of this balancing tube arrangement is that, if the diver is forced to suddenly submerge and has to don his mask while under water, he can do so and then press the knob 145 and thereby build up instantly a very high pressure in the mask without allowing any loss of pressure because of leakage out through the exhalation valves. To get rid of whatever water is in the mask he merely pulls the mask away from his chin, while still underwater, and the entrapped water will be instantly discharged.

The function of the knob 145 is to positively and manually push in the diaphragm 86 so as to open the demand valve 85 and fill the mask with air under very high pressure, so as to enable the entrapped water to be discharged immediately when the lower part of the mask is pulled away from the chin.

If something should go wrong with the various valves of the apparatus or the main hose 64, the diver simply opens the emergency valve 146 which allows high pressure air to flow up through the emergency hose 147 directly into the mask 46. The diver can also use this emergency valve 146 to instantly build up a high pressure in the mask and to discharge any water therein when the mask is pulled away from the chin of the diver.

If the diver (or his attendant) wants to recharge the air storage tanks 31, 31¹ with compressed air without removing said tanks from the back plate, he merely connects the charging valve 148 with a source of compressed air.

I claim:

1. A breathing apparatus including a breathing mask or the like and comprising: a casing supplied with breathing fluid under pressure; a reduction valve which controls the flow of said breathing fluid and discharges said fluid into a balancing chamber from whence it passes to the mask; a diaphragm controlling said reduction valve and subjected on one side to ambient pressure and subjected on its other side to the pressure in a pocket chamber; and a passageway connecting said pocket chamber and said balancing chamber, said passageway being substantially perpendicular to the flow of fluid from said balancing chamber.

2. A breathing apparatus including a breathing mask or the like and comprising: a casing supplied with breathing fluid under pressure; a reduction valve which controls the flow of said breathing fluid and discharges said fluid into a balancing chamber from whence it passes to the mask; a diaphragm controlling said reduction valve and subjected on one side to ambient pressure and subjected on its other side to the pressure in a pocket cham-

ber; and a venturi nozzle located in the path of the flow of fluid from said balancing chamber and tubularly connected with said pocket chamber.

3. A breathing apparatus including a breathing mask or the like and comprising: a casing supplied with breathing fluid under pressure; a reduction valve which controls the flow of said breathing fluid and discharges said fluid into a balancing chamber from whence it passes to the mask; a diaphragm controlling said reduction valve and subjected on one side to ambient pressure and subjected on its other side to the pressure in a pocket chamber; and a passageway connecting said pocket chamber and said balancing chamber, said passageway being substantially perpendicular to the flow of fluid from said balancing chamber and constituting the only free passageway between said pocket chamber and said balancing chamber.

4. A breathing apparatus including a breathing mask or the like and comprising: a demand valve compartment having a cylindrical bore; means for supplying breathing fluid to said compartment; a valve seat arranged at the one end of said compartment; a demand valve whose stem projects beyond said compartment and which is provided with a plurality of guide tits which slidably engage the bore of said compartment; means for actuating said demand valve in response to the pressure in the mask; and means for conducting the breathing fluid from said demand valve to the mask.

5. As in claim 4 with the further limitation that the entire demand valve, except for its stem and its tits, be encased in molded rubber.

6. A breathing apparatus including a breathing mask or the like and comprising: a regulator casing on said mask having an annular groove and an inclined surface arranged adjacent said groove; a diaphragm having an annular bead engaging said annular groove; an annular clamping ring engaging said inclined surface; a demand valve actuated by said diaphragm; and means for supplying said demand valve with breathing fluid.

7. A breathing apparatus including a breathing mask or the like and comprising: a regulator casing and a cover therefore, both having companion grooves and companion inclined surfaces adjacent said grooves; a diaphragm having an annular bead engaging said grooves; a U shaped clamping ring engaging aforesaid inclined surfaces; a demand valve actuated by said diaphragm; and means for supplying said demand valve with breathing fluid.

8. As in claim 7 but with the clamping ring split and covered by a U shaped, resilient sealing ring.

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